(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

10/516077

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 December 2003 (11.12.2003)

PCT

(10) International Publication Number
WO 03/102295 A1

(51) International Patent Classification[7]: D07B 1/02, D04C 1/12

(21) International Application Number: PCT/NL03/00396

(22) International Filing Date: 27 May 2003 (27.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

1020732	31 May 2002 (31.05.2002)	NL
02079571.2	1 November 2002 (01.11.2002)	EP
60/427,188	19 November 2002 (19.11.2002)	US
60/445,798	10 February 2003 (10.02.2003)	US

(71) Applicant *(for all designated States except US)*: **DSM IP ASSETS B.V.** [NL/NL]; Het Overloon 1, NL-6411 Te Heerlen (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SMEETS, Paulus, Johannes, Hyacinthus, Marie** [NL/NL]; Steegske 7, NL-6243 AK Geulle (NL). **DIRKS, Christiaan, Henri, Peter** [BE/BE]; Bautshoefstraat 13, B-3650 Dilsen (BE).

(74) Agent: **MOOIJ, Johannes, Jacobus**; DSM IP Assets B.V., Postbus 9, NL-6160 MA Geleen (NL).

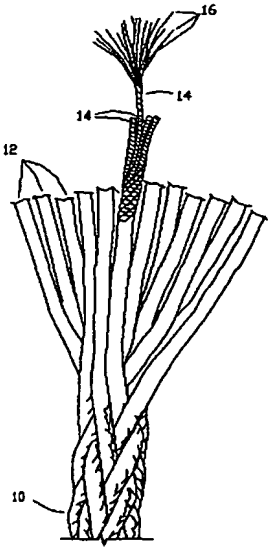
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ENDLESS ROPE



(57) Abstract: Endless rope (10) containing primary strands (12), the primary strands (12) containing laid-up secondary strands (14), the laid-up secondary strands (14) containing rope yarns (16), wherein the primary strands (12) have been laid up from 3,4 or 6 secondary strands (14), wherein the rope (10) contains a splice in at least every primary strand (12) and wherein the rope (10) preferably has been laid up from 3, 4 or (1+6) primary strands (12) or, alternatively, has been braided from 8 or 12 primary strands (12).

WO 03/102295 A1

ENDLESS ROPE

The invention relates to an endless rope containing primary strands, the primary strands containing laid-up secondary strands, the laid-up secondary strands containing rope yarns.

A rope construction for the manufacture of an endless rope is known from US-A-5901632, which describes a braided rope consisting of braided primary strands which in their turn consist of rope yarns. From this an endless rope can be manufactured by making a splice in the braided primary strand when during the manufacture of the rope a reel of a braided primary strand gets empty.

A rope containing primary strands, the primary strands containing laid-up secondary strands, the laid-up secondary strands containing rope yarns is known from US-A-4,170,921, which describes a braided rope consisting of primary strands which consist of laid-up secondary strands which in their turn are made up of twined rope yarns.

The primary strands consist of several secondary strands laid up parallel. Such ropes can in general be manufactured rapidly.

The drawback of such a rope, however, is that it cannot be used for the manufacture of endless rope. Where in the manufacture of such a rope a yarn reel runs empty, there is no possibility to connect a yarn to that of a following reel without considerable loss of strength.

The aim of the invention is to provide an endless rope.

It has been found to be possible to achieve this aim when in the rope according to the invention the primary strands are laid up from 3, 4 or 6 secondary strands yarns and the rope contains a splice in at least every primary strand.

An advantage of the rope according to the invention in comparison with the rope of US-A-5901632 is that the rope according to the invention can be manufactured faster, has a higher strength and is easier to splice.

Due to this it is achieved that an endless rope can be manufactured as will be further described below.

A rope which has been built up in several steps contains several construction elements. Examples of this are a yarn composed of twined or non-twined filaments, or a strand or a combination thereof, which can be composed of laid-up or

braided yarns or thinner strands.

In the rope according to the invention the primary strands can be braided or laid up with each other.

If the rope has been laid up, the rope has preferably been laid up from 3, 4 or (1+6) primary strands.

If the rope has been braided, the rope has preferably been braided from 8 or 12 primary strands.

In the rope according to the invention the primary strands have been laid up from 3, 4 or 6 secondary strands.

In general the secondary strands, depending on the size of the rope ultimately to be obtained, contain several twined rope yarns which can have been divided over several layers in these strands.

The rope yarns in the rope according to the invention contain several fibres. The fibres in the rope yarn can be smooth or twined.

If successive construction elements both contain a twist, the twist directions are preferably opposite in successive construction elements.

An advantage of the rope according to the invention is the fact that if during the use of the rope some strands get damaged, they can be renewed without the need to take off the entire rope. Also, the rope according to the invention has a better wear resistance than known ropes.

A problem involved in the manufacture of an endless rope is that there are limits to the diameter of the reels carrying the primary strands, so that the wound-up length of the primary strands is finite and the reels will get empty during the production of rope. For the manufacture of an endless rope now, the tail end of a first strand on a reel that gets empty has to be connected to the lead end of a second strand on a new reel.

This can be done simply now with the rope of the invention by splicing the tail end of the first strand to the lead end of the second strand with application of a standard splicing technique. By making such splices at successive spots in each of the primary strands an endless rope can be manufactured without significant loss of strength of the rope.

Ropes with a diameter of 20 mm or more are mostly produced from strands the yarns of which are built up in several layers. A strand is in general composed of a core, consisting for instance of 3 rope yarns, with around it several layers consisting of multiple rope yarns. In such a strand no splice can be made. The

length of such a rope is therefore limited by the volume of the braiding bobbins on a braiding machine for braided rope or by the volume of the reels on a rope-laying machine for a laid-up rope.

An extra advantage of the rope according to the invention is that its thickness does not involve any restriction of its length, because a splice can be made herein. The invention therefore preferably relates to an endless rope having a diameter of more than 20 mm. The length of the endless rope is more than 250 metres, preferably more than 1000 metres.

Figure 1 shows one of the embodiments of the rope according to the invention, being a 12-strand braided rope (10), which consists of 4-strand laid-up primary strands (12) with an S-twist. The primary strands consist of secondary strands (14) which have been laid up from rope yarns (16) in a Z-twist. Normally half of the strands consist of an S-twist and the other half of a Z-twist.

For the manufacture of such a rope, rope yarns (16) can be twined from a bundle of fibres with the help of a standard twining machine. A secondary strand (14) is then laid up from several rope yarns on a strand bench, with the direction of twist being opposite to the direction of twist in the rope yarn. Four of those strands are laid up to form the primary strand (12). Then 12 primary strands are braided to form the rope (10). This is done on a braiding machine with 12 reels which are filled with primary strands. An endless rope can be made now by, when one of the reels gets empty, connecting the tail end of a first primary strand on the empty reel to the lead end of a second primary strand on a full reel and replacing the empty reel by the full reel. Connecting the two strand ends can be done by applying a splice in accordance with a known method as described for instance in The Splicing Handbook, "Techniques for Modern and Traditional Ropes", by Barbara Merry with John Darwin, ISBN 0-87742-952-9.

Another, more preferable method is a method wherein:

a) one end of a first primary strand end is split in a first and a second part comprising respectively a first and a second number of secondary strands, the first part having at most one more secondary strands than the second part
b) the first part is tucked from one side in an opening in the second primary strand, such that the opening has a first number secondary of strands on one side and a second number of secondary strands on the other side, where the first and second number differ at most by one,
c) the second part is tucked from the other side in the opening in the second

primary strand

step b) and c) are repeated at least 3, respectively 3+1 times, whereby the respective openings in the second primary strand end are separated such that the first and the second part have crossed over at least all the secondary strands of the second primary strand once and the first and second part leave the second primary strand at respective last openings.

In this method one end of a first primary strand is split in a first and a second part comprising respectively a first and a second number of secondary strands, the first part having at most one more strands than the second part. This means that a 3-strand primary strand is split in a first part with 2 secondary strands and a second part with only 1 secondary strand. A 4-strand primary strand is split in two parts of 2 secondary strands and a 6-strand primary strand in two parts of 3 strands.

When the first and second primary strand have 3 strands each, the said opening has 2 strands on one side and 1 strand on the other side. When the first and second rope has 4 or 6 strands the said opening has 2, respectively 3 strands on both sides.

The second part is tucked from the other side in the opening in the second primary strand, which implies that both parts of the first primary strand are tucked in different directions through the opening in the second primary strand.

Step b) and c) are repeated at least 3 times, whereby the respective openings are separated such that the first and the second part have crossed over at least all the secondary strands of the second primary strand once and the first and second part leave the second primary strand at respective last openings. The sequence wherein step b) and c) are repeated is of no importance for the efficiency of the resulting splice.

An advantage of this splice is, that with this method a splice is much faster to produce.

The ropes can be made from different yarns. Suitable yarns are polyester, nylon, polyethylene, polypropylene, aramide, polybenzoxazole (PBO) and "High Modulus PolyEthylene (HMPE) as Dyneema® or Spectra®.

The endless rope according to the invention preferably contains HMPE yarns.

The invention will be further elucidated by means of the following non-restrictive example and comparative example in which the primary strands have been laid up and braided, respectively.

Example I

Rope (1) has been built up from laid-up strands (3 x 1(8/1760 dTex Dyneema SK-75), with a lay-up length of 34 mm and a weight of 4.27 g/m,). The breaking strength of such a strand is 10797 N.

On a Ratera braider these strands were made into a 12-strand braided rope with a braid length of 8x the diameter. The weight of the rope was 54.6 g/m. The rope had a breaking strength of 77820 N.

Comparative experiment A

Rope (2) has been built up from braided strands (8 x 1(3/1760 dTex Dyneema SK-75), with 12 picks per 10 cm and a weight of 4.37 g/m. The breaking strength of such a strand is 9670 N.

On a Ratera braider these strands were made into a 12-strand braided rope with a braid length of 8x the diameter. The weight of the rope was 56 g/m. The rope had a breaking strength of 61740 N.

From this it appears that the strand strength of the laid-up construction is about 15% higher than that of the braided construction.

Although the strand strength of the laid-up construction is only 15% higher than that of the braided construction, the strength of the rope made of it surprisingly is 26% higher than the strength of the rope made from the braided construction. Further, the construction stretch of the braid with the braided strands is significantly higher than in the case of the laid-up strand.

Example II

In the rope (1) a standard splice is made as described in The Splicing Handbook, "Techniques for Modern and Traditional Ropes", by Barbara Merry with John Darwin, ISBN 0-87742-952-9.

The splice was impregnated with a coating (LAGO 50, from GOVI, Belgium), which made it possible to use a much shorter splice length than for a non-coated splice in a Dyneema rope.

In rope (1) two types of end connection were tested:

i) splicing together two strand ends to be connected, with a total of 24 tucks, the last 3 of which were thinned. The breaking strength of a rope with such a splice amounted to 67990 N. When the number of tucks is 27 and the last 3 are thinned, the breaking strength amounts to 81660 N.

ii) making two loops hooking into each other by splicing back into each other the two strand ends, with 16 tucks. This has a breaking strength of 70550 N.

This shows that a spliced-in connection does not cause a loss of strength for the spliced-up strands if this is done optimally, i.e. if a sufficient number of tucks is made.

However, if loops are used to make the connection, this results in loss of breaking strength and this connection disturbs the structure of the 12-strand production braid which is unacceptable in view of the use of the braid.

CLAIMS

1. Endless rope containing primary strands, the primary strands containing laid-up secondary strands, the laid-up secondary strands containing rope yarns, wherein the primary strands have been laid up from 3, 4 or 6 secondary strands and the rope contains a splice in at least every primary strand.
2. Endless rope according to claim 1, wherein the rope has been laid up from 3, 4 or (1+6) primary strands.
3. Endless rope according to claim 1, wherein the rope has been braided from 8 or 12 primary strands.
4. Endless rope according to anyone of claims 1-3, wherein the rope contains HMPE yarns.
5. Endless rope according to any one of claims 1-4 , wherein the diameter of the rope is more than 20 mm.
6. Endless rope according to claim 5, wherein the length of the rope is more than 1000 metres.

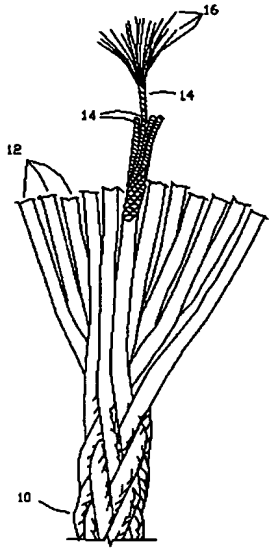


FIGURE 1/1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 03/00396

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D07B1/02 D04C1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D07B D04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 181 344 A (A.J. RICK) 28 November 1939 (1939-11-28) page 2, column 1, line 60 - line 72 ---	1,2
A	US 2 281 036 A (J.A. HETZEL) 28 April 1942 (1942-04-28) page 2, column 1, line 10 - line 48 ---	1
A	US 4 170 921 A (G.H. REPASS) 16 October 1979 (1979-10-16) cited in the application column 3, line 18 - line 63 ---	1
A	US 5 901 632 A (R.J. RYAN) 11 May 1999 (1999-05-11) cited in the application column 4, line 38 -column 5, line 21 column 6, line 14 - line 53 --- -/--	1,3,4

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 October 2003	13/10/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Goodall, C

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 03/00396

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 600 395 A (J.J. DOMOJ; S. ROSENBERG) 17 June 1952 (1952-06-17)	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 03/00396

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2181344 A	28-11-1939	NONE	
US 2281036 A	28-04-1942	NONE	
US 4170921 A	16-10-1979	NONE	
US 5901632 A	11-05-1999	US 5931076 A	03-08-1999
US 2600395 A	17-06-1952	NONE	